Systems of Demographic Measurement

Data Collection Systems: National Dual Record and Related Systems

Le Programme International des Laboratoires pour les Statistiques de la Population se consacre au perfectionnement des méthodes de mesure de variation des populations et à l'analyse des données démographiques. C'est dans ce but que le Programme cherche à établir et à subventionner des laboratoires d'expériences où de nouvelles méthodes de mesure puissent être expérimentées, et où, dans les cas appropriés, l'analyse de données déjà existantes puisse être développée. Ces projets sont basés sur la coopération entre l'Université de la Caroline du Nord à Chapel Hill et les institutions scientifiques de divers pays. Le programme se réalise grâce à la participation de ces institutions et à l'assistance apportée par l'Agence pour le Développement International du Gouvernement des Etats-Unis. Des publications scientifiques et techniques sont distribuées gratuitement à un nombre limité d'institutions et de particuliers qui s'intéressent aux problèmes de mesure démographique. Les opinions émises et les conclusions exprimées sont celles de leurs auteurs respectifs, sans engager les institutions dont ils dépendent.

El Programa Internacional para Estadísticas de Población se dedica a la investigación de mejores métodos para la medición de cambios poblacionales y al análisis de datos demográficos. Con este fin, el Programa espera establecer y mantener laboratorios experimentales en los cuales se puedan ensayar nuevos métodos de medición y, cuando sea apropiado, analizar datos existentes. Los proyectos se basan en acuerdos cooperativos entre la Universidad de Carolina del Norte en Chapel Hill e instituciones científicas de varios países. El Programa se lleva a cabo gracias a la participación de estas instituciones y a la asistencia de la Agencia para el Desarrollo Internacional del Gobierno de los Estados Unidos. Publicaciones científicas y técnicas son distribuídas, sin costo alguno, a un número limitado de instituciones y personas interesadas en problemas de medición demográfica. Las diferentes opiniones y conclusiones expresadas son responsabilidad de los autores respectivos, y no deben ser atribuídas a las instituciones patrocinadoras.

The International Program of Laborato cated to research on improved methods change and to the analysis of demograp gram seeks to establish and support exp measurement methodology can be tested of existing data can be developed. Proj ments between the University of North institutions in various countries. This p participation of these institutions and International Development of the Gover and technical publications are distributed of institutions and individuals concer problems. The opinions and conclusions authors and should not be attributed to

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Les systèmes de double collecte pour la mesure des taux démographiques sont en train d'émerger en tant que systèmes statistiques de plein droit. De tels systèmes engend-ont leur propre contrôle, se prêtent à l'experimentation, à l'étude des erreurs de mesure et à la production de données de qualité éprouvée. Le principal désavantage en est leur coût élevé, en comparaison des systèmes simples, ceci de par leur administration complexe et le taux élevé de personnel bien entrainé qu'ils requièrent. Le total des erreurs d'estimation peut être considérablement plus bas dans un système de double collecte que dans un système simple avec un échantillon beaucoup plus grand; l'efficacité peut être donc plus élevée.

En plus de produire des données de meilleure qualité, les systèmes de double collecte fournissent une structure pour l'évaluation de différents systèmes simples de mesure de la fécondité et de la mortalité. A l'intérieur même des systèmes de double collecte de nombreuses questions restent à résoudre, telles que: la détermination de l'échantillon dans le temps et dans l'espace; les meilleurs sous-systèmes; les procédés de couplage; les erreurs de délimitation; l'effet de sous-systèmes quasi indépendants sur les estimations et les méthodes d'analyse.

Dual record systems for measuring vital rates are emerging as statistical systems in their own right. Such systems are self-checking and hence lend themselves to experimentation, the study of measurement errors, and the production of data of known quality. The major disadvantage is the higher cost, as compared with single systems, because of the complex administration and the relatively high ratio of well-trained personnel required. The total error of estimates from dual systems may be considerably lower than in a single system with a much larger sample; the result may hence be more efficient.

In addition to providing better quality data, dual systems provide a framework for evaluating different single systems for measuring fertility and mortality. Within dual systems many questions, such as the following, require answers: sample design in time and space; the best subsystems; matching procedures; boundary errors; the effect of quasi-independent subsystems on estimates, and methods of analysis.

El sistema de doble registro para la medición de tasas vitales está emergiendo como sistema estadístico independiente. Este sistema tiene la cualidad de comprobarse a sí mismo y por lo tanto se presta para la experimentación, el estudio de los errores en medición, y la producción de datos de reconocida calidad. Su mayor desventaja es el alto costo, comparado con sistemas sencillos, debido a la compleja estructura administrativa y a la alta proporción de personal bien entrenado que requiere. El total de errores de estimación a través del método de doble registro puede ser considerablemente inferior a los obtenidos usando un sistema sencillo con una muestra mucho más grande; de esta manera, su resultado puede ser por lo tanto más eficiente.

Además de proveer datos de mayor calidad, los sistemas de doble registro proveen de un marco de trabajo para la evaluación de diferentes sistemas sencillos para medir fecundidad y mortalidad. Con relación a los sistemas de doble registro surgen muchas preguntas que requieren de una respuesta: diseño muestral en el tiempo y espacio; cuál es el mejor subsistema; procedimientos de confrontación; errores de límites; el efecto de subsistemas cuasi-independientes en las estimaciones, y métodos de análisis.

Contents

I. Introduction

The development of sound vital registration systems has been a dominant concern in recommendations made for improving birth and death statistics. It now appears, however, that in some developing countries this must perhaps be given lower priority than the development of sound estimates of vital rates. Hauser (1954, p. 20) in discussing the use of sampling for the improvement of civil registration systems, acknowledged that "use of the survey method in conjunction with the vital registration system has great potentialities and merits careful consideration." He was referring specifically to the Chandrasekaran-Deming approach (1949) which, as Coale later pointed out, was a formal elaboration of the matching procedures actually used in the U.S. birth registration tests of 1940 and 1950 (Coale, 1963). Coale (1963, p. 372) then summarized the major elements required for an experimental system to be applied in a national sample, as follows:

The underlying technique is to obtain data on individual events in the sample area by two independent means. The events recorded by each means of measurement must be identified accurately enough to establish a "match" of the two records of the same event.

The two independent means envisioned by Coale were: (1) either an improved civil registration system or a wholly new registration scheme; and (2) a periodic household survey with retrospective questions on demographic events.

Extensive experimental trials of Coale's proposed approach for measuring national fertility, mortality, and population growth rates, have been conducted in Pakistan (Pakistan Institute of Development Economics, 1968), Turkey (Rumford, Heperkan and Fincancioglu, 1968), and Thailand (Thailand, 1966). National systems are now in operation in India (India, 1970a) and Liberia (Rumford, 1970). Experience in these countries has been described in several numbers of the Scientific Report Series issued by the International Program of Laboratories for Population Statistics. Such systems are relatively expensive in comparison with single-visit, retrospective surveys and are more

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difficult to administer (Brass, 1968a; Mauldin, 1966). Many problems have been encountered in these systems, and many are still not resolved. Nevertheless, experience to date has been favorable and, because of their cross-checking features, these systems appear to offer the most reliable procedure for obtaining vital rates in countries where registration is inadequate.

This paper discusses in some detail the elements of these systems and outlines some unsolved problems and research questions related to these systems. As background, some of the comparative features of the countrywide systems are briefly reviewed.

Various terms have been used to describe these systems of population measurement. In the POPLAB Publication Program, the use of the phrase *The Dual Record System* has been restricted to those systems in which two special records are obtained through data collection procedures that are independent of the legal registration system. The first of the two records of the system is a *vital event record* which is compiled currently and continuously for each birth and death by some form of continuous recording that is independent of the official vital registration mechanism. The second record, the *survey record*, is created by a series of independent periodic household interview surveys. These surveys collect retrospective information on births and deaths which can be matched with the vital event record obtained by the continuous recording procedure, thus producing by the Chandrasekaran-Deming method an estimate of the number of events missed by both procedures.

Since the vital event record is created solely for statistical purposes there are no barriers to extending the coverage of items as far as desirable. Similarly, the *survey record* is also specially designed for demographic purposes and is not restricted by the demands placed on multipurpose censuses or surveys.

In general, an attempt has been made to follow this nomenclature in the present report. In some instances, notably in the case of the Thai system which uses civil registration as one source of records, the term *dual record system* has been used more broadly to refer to closely related systems that do not conform exactly to the definition given above.

Most of the techniques and problems considered in this paper are well known to those directly involved in the organization and management of field and analytical work. For example, since 1964 in India the Office of the Registrar General has sponsored the Annual Inter-State Conference on Sample Registration as a forum for discussion of technical and operational problems in the various states (India, 1970b). A review of the agenda for these six meetings provides an interesting capsule history of the evolution of that system to the present time. An increasing number of papers and reports about individual country systems are also appearing, although some of these may not yet be in wide international circulation.

In addition to these materials on individual country systems, a growing literature on the problems of dual record systems is being written by demographers and statisticians. Since the 1963 paper by Coale and one by Krotki (1963), other papers related to some aspect of dual record systems have appeared with increasing regularity in international and regional meetings of professionals concerned with population problems. The Population Council held a series of special seminars during 1970 on *Problems of Population Growth Estimation* as a basis for the preparation of a *Handbook for Population Growth Estimation Surveys* (Population Council, 1970). In 1970, the Laboratories for Population Statistics (POPLAB) at the University of North Carolina at Chapel Hill initiated regular annual conferences for the review and discussion of problems encountered, including those of dual record system experiments being carried out in the field (Linder, 1971).

Some comparative analyses of the features of dual record systems have already been done. Both Mauldin (1966) and Heisel (1968) have discussed the problems and features of the Pakistan (PGE) experiment and compared it with other special systems for obtaining vital statistics. Lauriat (1967) compared early problems and features of the Pakistan, Thailand, and Turkey systems. Abernathy and Lunde (1970) reviewed and compared the features and problems of all five country systems, including India and Liberia, in somewhat more detail than had been done before. Seltzer (1969) reviewed coverage estimates of different systems in 19 Asian dual record studies. Krotki (1970) prepared a brief review reiterating problems and features of dual record systems for estimating population growth. Linder (1969) compared the features of different methods of population measurement using the systems analysis approach.

II. Early and Related Methods Research Studies

Dual record systems involving quasi-independent subsystems can be viewed as a special case of multiple record systems, such as reinterviews, record check studies, multiple-visit surveys, and others, in which two or more sources of data are matched for each individual and results are used either to update the record for the individual or to evaluate coverage or quality of data. Zarkovich (1966) has described use of such methods in his book on the quality of statistical data.

Testing of birth registration completeness in the United States evolved from matching relatively incomplete lists of newborn infants obtained from newspapers, death records, and school censuses in 1917–1920 to matching relatively complete lists of living infants enumerated in the 1940 and 1950 censuses with registered birth records for the same periods (Shapiro, 1950; 1954). The problems of matching, illegible and inaccurate entries, out-of-scope events, and other problems that plague dual record systems today were encountered in these early studies. Initial matches were done by hand in 1940 and by punched card equipment in 1950. Careful and precise written rules for matching were devised and applied. Initial matches were made at the national level with mail follow-up of unmatched cases; further matching of records was done in state offices of vital statistics where cross-referenced indexes were maintained.

Chandrasekaran and Deming (1949) developed estimation procedures for the total number of vital events and its variance. Events found by two independent subsystems are classified into three mutually exclusive categories: (1) identified by both systems; (2) identified only by the first system; (3) identified only by the second system, and then, assuming independence, the number missed by both is obtained.[1] Procedures were also developed to improve the estimates when events could be subdivided into categories within which there was no correlation between systems. The theory was applied to obtain estimates for the Singur Health Center area using registration data for 1945 and 1946 matched against events found through a retrospective household survey conducted during February–April

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[1] This is the same as simple capture-recapture models used in estimation of animal populations as pointed out by Som (1969).

1947. Percentage coverage estimates were as follows:

System	Births		Deaths	
	1945	1946	1945	1946
Civil Registration	52	60	48	51
Survey (Early 1947)	53	67	32	51

Source: W. Seltzer. 1969. Some Results from Asian Population Growth Studies. Population Studies 23(3):395–406.

A major methodological study in Mysore (United Nations, D.E.S.A., 1961) concerned primarily the evaluation of problems of measuring population change through one-time sample surveys. There again, to obtain estimates of completeness of coverage, Chandrasekaran matched vital records against survey results in rural zones and also matched results of two surveys in urban areas. Matching of survey and registration lists was limited to those villages that maintained registers and was further limited to events that occurred in those villages.

A number of methodological experiments conducted in connection with demographic and other types of surveys are pertinent to the design of dual record systems. These include tests of factors influencing the completeness of reporting past events, e.g., Neter and Waksberg (1965), Jain (1970), Som (1969), United Nations, E. C. A. (1964), Zarkovich (1966), and Horvitz (1966); evaluations of longitudinal studies (Gunasekaran, 1970; Katchirayan, 1969; Singh, 1968; Srinivasan, et al. 1969; Sabagh and Scott, 1967); and matching methodology (Srinivasan and Muthiah, 1968; Mehta, 1970).

III. Countrywide Dual Record Systems: A Comparison of Features and Problems

The characteristics of the systems with which this paper is primarily concerned are essentially restricted to design and methods. These are compared in Table 1 for the five countries being considered. The Pakistan survey, beginning in 1962, was the first study. Pilot studies began the following year in India and Turkey, but actual, full-scale work started earlier in Thailand than in those two countries. Work in Liberia began in 1969; that survey, together with the survey in India, is continuing to the present time.

A. ADMINISTRATIVE SETTINGS

These five country systems have been funded, at least partially, by special grants but have been managed by existing government organizations as follows:

Country	Responsible Organization	Collaborating Organizations
Pakistan	Pakistan Institute of Development Economics	Central Statistical Organization
Thailand	National Statistical Office	Ministry of Interior
India	Office of the Registrar General	State Organizations for Health Statistics or Economics and Statistics
Turkey	School of Public Health, Ankara	State Institute of Statistics; Hacettepe University
Liberia	Department of Planning and Economic Affairs	None

Complex problems of implementation were encountered in India where, in the early years, state governments were asked to share costs. Consequently, the Office of the Registrar General faced the task of convincing sometimes reluctant state officials of the need for sample registration (Wells and Agrawal, 1967). State resources and priorities differ, and, even when a state agrees to take on sample registration, the implementing agencies usually have other ongoing statistical programs with which a new project must compete for the available technical personnel. Recruiting, training, and supervision of additional staff under officially sanctioned

TABLE 1.
Characteristics of Five Countrywide Dual Record Systems*

Country and Name of Study	Period of Coverage	Estimates for	Sample Size (Persons)	Area Sample Units
1. Pakistan Population Growth Estimation Experiment (PGE)	January 1962– December 1964	East Pakistan West Pakistan	120,000	24 (clusters) compact sample areas averaging 5,000 persons each
2. Thailand Survey of Population Change (SPC)	July 1964– June 1967	Whole Kingdom	170,000	60 districts, 5–6 whole villages per district Bangkok excluded
3 India Sample Registration Scheme (SRS)	1964 rural began 1968 urban began (uneven implementation by state) Continuing	Each State as of 1970; 16 rural 8 urban	Rural: 43,000–275,000 per state Urban: 41,000–91,000 per state	Rural area stratified into 12–16 strata based upon topography and village population in 1960, 50–150 villages per state Urban, 60–100 blocks of about 750–1000 persons each per state
4. Turkey Turkish Demographic Survey (TDS)	Phased Implementation September 1965–1967 Continuing	Five regions, rural and urban. Three largest cities	450,000	60 villages per region for rural areas 30–60 blocks of about 100 households each for urban areas and for each of the large cities
5. Liberia Liberian Population Growth Survey (PGS)	May 1969 Continuing	Urban places Rural places	70,000 total 50,000 rural 20,000 urban	100 villages in 50 clans (counties) for rural area 100 blocks of about 200 persons each in urban areas

* Modeled on related analyses by Lauriat (1967), Seltzer (1969), and Abernathy and Lunde (1970).

TABLE 1. (*Continued*)

Data Collection: Continuous Recording Subsystem

Study	Staff	Method(s) of Recording	Reports	Supervision	Special Efforts
1. PGE	Full-time local resident recorder	Special system. Establishes system of "informants"; makes regular rounds, maintains a list of births and deaths.	Monthly report of events to headquarters. List of events withdrawn before quarterly survey.	By full-time PGE survey staff. Later by Survey Officers also.	*Unofficial* birth and death certificates issued.
2. SPC	Civil registration officials	Events recorded at commune level (a group of villages). Register maintained at district level.	Events copied from district registers by clerks from survey headquarters.	Clerks by full-time survey staff. Civil registration unknown.	Efforts to get reports directly from commune level in later years.
3. SRS	Part-time local resident recorder	Special system. Rural: establishes system of informants, makes regular rounds, maintains list of events. Urban: monthly visit to each household to ask about events.	Monthly report of events to state headquarters. List of events is withdrawn before six-month survey.	By part-time survey interviewers, occasionally by full-time survey staff.	List of pregnant women maintained. Quarterly recorder visit to all households to detect events missed by recorder in rural units.
4. TDS	Part-time local resident recorder	Monthly visit to each household. Updates household list and records all events.	Copy of new updated household records to headquarters each month.	By full-time staff—usually visit at time of field verification.	Unknown.
5. PGS	Part-time local resident recorder	Monthly visit to each household. Updates household list and records all events.	Copy of new updated household records to headquarters each month.	By full-time staff: field inspector and division supervisor.	Lists of pregnant women and seriously ill persons maintained. Cash payment per verified event recorded. Letters of congratulations (birth) and condolences (deaths).

TABLE 1. (*Continued*)

Study	Staff	Data Collection: Household Survey Subsystem			
		Frequency	Events Recorded	Reference Period	Storage of Records
1. PGE	Full-time non-resident staff of project and central statistical organization	Full new household enumeration annually. Follow-up visit quarterly between enumerations using H.H. list.	*De facto* births and deaths. Changes in household members. List of pregnant women.	"Past 12 months" (four overlaps)	Original kept and used by interviewer for each quarterly round except new ones. Duplicate to headquarters after each new annual, updated by quarterly change reports.
2. SPC	Full-time nonresident project interviewers	Baseline full household enumeration. Quarterly updating visit.	*De jure* births and deaths. Changes in household members. Also pregnant women and seriously ill persons.	"Since last survey round"	Original kept and used by interviewer for each quarterly round. Duplicate at headquarters updated by quarterly change reports.
3. SRS	Part-time nonresident interviewers	Baseline full household enumeration by recorder. Nonresident staff updates existing H.H. data every six months using previous list.	*De facto* and *de jure* births, deaths and stillbirths. Changes in household members.	"Since last survey round"	Kept by local recorder. Used during six-month updating by interviewer and as basis for population tabulations.
4. TDS	Full-time nonresident project interviewers	Baseline enumeration by local resident recorder. New independent enumeration every six months by project interviewer.	*De jure* births, stillbirths, and deaths. In-migrants and out-migrants.	First new survey each year "past six months." Second new survey each year "past year" (one overlap).	Original to central office.
5. PGS	Full-time non-resident project interviewers	Baseline by interviewer and recorder. New independent enumeration every six months by team of project interviewers.	*De jure* births, stillbirths, and deaths. In-migrants and out-migrants.	First new survey each year "past six months." Second new survey each year "past year" (one overlap).	Original to central office. Copy used by recorder to start new year.

TABLE 1. (Continued)

Study	Frequency and Place	Matching		Field Recheck		Tabulation Methods	Vital Event Estimation Procedure
		Events and Initial Match	Events	Staff			
1. PGE	Annual in headquarters	Machine match of punched cards with manual check	Unmatched events—field checked	Third Party	Mechanical vital events and population	Chandra-Deming *de facto*
2. SPC	Semi-annual or quarterly district level	Manual match birth and death reports	Only unsurveyed recorded events field checked	Third party—clerks who transcribed vital events	Mechanical vital events and population	Chandra-Deming *de jure*
3. SRS	Semi-annual at district or state headquarters	Manual match. Lists of births and deaths	Same lists unmatched events field checked	Third party or survey interviewer and recorder	Hand—vital events at headquarters; population at sample unit	Unduplicated count of *de jure* events found by both methods
4. TDS	Semi-annual in headquarters	Manual match cumulative recorder's H.H. record with new survey record	Unmatched events—letter or field check	Third party	Mechanical vital events and population	Chandra-Deming *de jure*
5. PGS	Semi-annual in headquarters	Manual match H.H. record, births, deaths, migrations with new survey record	Unmatched events—field checked	Third party, with survey interviewer and recorder	Mechanical vital events and population	Chandra-Deming *de jure*

programs usually have to be done under existing rules and regulations, with the result that implementation is sometimes delayed. These problems are particularly salient in the decentralized Indian system, but similar difficulties no doubt will be encountered at the national level in initiating new systems in other countries. Thailand's experience offers a case study (Lauriat, 1967) similar to that of the Guanabara panel survey (United Nations, D.E.S.A., 1964) of how the quality of field work can be influenced by personnel policies and field staff organization. Such administrative problems are of course not peculiar to dual record systems and are common to any special or new program.

B. SAMPLE DESIGNS

The designs for all five countries have included cluster samples, usually *villages* in rural areas and *blocks* in urban areas. Two contrasts in design are noteworthy: (1) samples for most Indian states are as large as the other whole country samples, and (2) the Pakistan sample was split into only 24 clusters (the dual record system was tried in only 16 of these, with recording alone in 4 clusters and survey alone in the remaining 4).

C. METHODS OF FIELD IDENTIFICATION

Difficult problems have arisen in the clear and unambiguous identification of area sample units in the field. Even when census data by village and for subdivisions of large towns and cities are adequate for selection of probability samples, boundaries of census enumeration districts and villages are often difficult to identify in the field. Inaccurate identification of the sample area resulting from random errors rather than from deliberate choice may not seriously bias estimates of vital rates, provided the inaccurate boundaries are observed consistently by both subsystems.[2] On the other hand, the use of different boundaries by the two subsystems for the same period or by the same subsystem at different times may result in biased estimates of rates because errors in estimated numbers for either numerators or denominators. Use of different boundaries at the

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[2] Inaccurately drawn boundaries can, however, introduce serious biases into population estimates based upon the sample areas.

same point in time by two subsystems is a hazard not faced in a single, one-visit survey, but it is a hazard in periodic surveys.

Although such problems were anticipated, the full extent of the difficulties in identification of boundaries, and especially in drawing maps, was probably much greater than expected. Maps accurate enough that different field workers can consistently identify at any time exactly which dwellings are inside or outside of a sample area are a prerequisite of a successful dual record system. In India, Turkey, and Liberia, the baseline surveys have been done either by local recorders alone or in cooperation with survey interviewers, thus decreasing independence. In India the local recorder is also custodian of the household records in the period between surveys. Preparation of fresh, annual household lists have been features of the systems in Pakistan, Turkey, and Liberia, while the original household lists have been merely updated at each round in India and Thailand.

Establishing and maintaining a house-numbering system is a formidable task. Identification of new dwellings, as well as change in the use of old dwellings and households within sample areas, are related to mapping. Most of the country systems have attempted to use either existing or special systems for numbering dwelling units within each sample area. Additional problems are created in identifying clearly the different households in multi-household dwellings. Again, these identification problems exist for any survey or revisit procedure involving follow-up visits to the same household or individual.

Migration, either permanent or temporary, has been another problem. Thailand originally tried to trace a sample of individuals and to follow all people within fixed sample areas, but because of migration the plan to trace individuals failed and was abandoned. Both Turkey and Liberia report large volumes of net migration. In India and Pakistan, young wives who live in the home of the husband's family often return to their own families (outside the sample village) for the birth of a child.

Given independent subsystems, the Chandrasekaran-Deming estimation procedure could also be used to obtain estimates of total migrants analogous to estimates of births and deaths, but Rumford (1970) feels that this should not be done because of serious departures from the independence assumptions. High migration rates, the differences in the

ability of periodic surveys as compared with that of local recorders (monthly household visits) to detect migration, and the vital events associated with migrants all indicate the need for special techniques both to improve the probability of detecting associated events and to develop modified estimation procedures for obtaining mortality and fertility rates.

D. CONTINUOUS RECORDING

All countries, except Thailand, elected to use a *special* recording system rather than the existing civil registration system. In Turkey and Liberia, this literally means a monthly visit to each household by a local recorder[3] to detect and record events by asking about changes in the household. India also follows a system of monthly household visits by the recorder in urban areas. In rural areas emphasis has been given to development of a system of informants[4] (midwives, watchmen, religious functionaries, etc.) as a source of information on births and deaths. Recently a quarterly visit to households has been incorporated into the procedures used in rural India to detect events missed through the informant system. Pakistan relied exclusively on the use of informants. The Pakistan and India recording subsystems are, however, more "active" than "passive" in the sense that the recorder first uses informants to find out about events and then goes to the household to obtain details and to record them rather than waiting in an office for someone to report the event.

Problems in maintaining the interest of local informants over an extended time period were encountered in both Pakistan and India. Moreover, a further problem emerged in sustaining the interest of the recorders themselves, especially part-time ones, who encounter relatively few vital events per week. For example, in Turkey (Rumford, Heperkan and Fincancioglu, 1968), local recorders apparently missed many events because they felt they were familiar enough with their village to find out about

events without making monthly visits to each household.

Supervision of recorders and survey interviewers has been a problem in most countries either because many supervisors have other responsibilities or because there are too few supervisors. Supervision of special recorders in most instances is done by either full- or part-time staff members who also have responsibilities for supervision or matching work. This creates situations that tend to reduce independence between the recording and survey subsystems. Greater degrees of independence between subsystems apparently were maintained in Pakistan and Thailand than in the other systems. Even in those, however, there was some sharing of effort in different phases of work. For example, in Pakistan survey interviewers from the Central Statistical Organization took over day-to-day administrative control of the recording field staff after one and a half years (Krotki and Ahmed, 1964); in Thailand the clerks who transcribed vital events from district and municipal registers also did field investigations of registered events not found in the survey (Thailand, 1966). With the techniques and analyses employed thus far, it is impossible to determine the extent to which lack of independence between subsystems has influenced estimates of vital rates obtained in the several countries.

Special efforts have been made to enhance and promote detection and recording of vital events. Pregnancy lists were used apparently without much success in Pakistan and Thailand by survey staff and in India by recorders (Pakistan, 1968; Lauriat, 1967; Agrawal, 1969), but in Liberia they have been quite successful (Rumford, 1970). Listing of seriously ill persons has not been very successful (Lauriat, 1967; Rumford, 1970). Unofficial certificates about events given to household members apparently were quite useful (Pakistan, 1968; Rumford, 1970). Incentive payments for each verified event have been tried, apparently with success, in Liberia (Rumford, 1970).

All special systems require monthly recording reports to be sent directly to headquarters, except in Liberia where they are routed through district offices.

E. PERIODIC RETROSPECTIVE SURVEYS

Pakistan used 12-month recall periods in the quarterly survey, which overlapped three other

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[3] Different titles are used in the different countries for the person who does continuous recording. For simplicity the term *recorder* is used in this paper. Similarly, *interviewer* is used here to refer to those conducting the survey.

[4] Subsequent to the writing of this paper, POPLAB has adopted the term *community contact* for *informant*.

periods and, theoretically, should have given four independent chances to enumerate each event. However, an event would be "found" at every subsequent fill-up round (Krotki and Ahmed, 1964) simply because it was already on the record used. Presumably this cannot happen in Turkey and Liberia where fresh schedules are filled out at each 6-month visit by survey interviewers. In Turkey and Liberia, variable length reference periods of 6 and 12 months are used within each survey year for the 6-month and 12-month survey visits respectively, resulting in overlap for the first half of each year (Liberia, 1969). Neither India nor Thailand used overlapping reference periods.

Adhering to reasonable time schedules for completion of period survey field work has been difficult because of weather, transportation, and lack of adequate staff. Thus, planned, 6-month intervals between visits have sometimes been extended to 8 or 10 months, or even longer. It may require as long as four to six weeks to complete interviews in one unit.

F. MATCHING PROCEDURES

The matching process creates problems that are peculiar to dual record systems, although they are similar to those encountered in any multi-record survey procedure. Matching problems arise from other elements of the system such as maps, boundaries, house numbers, migration, and recall errors. Poor and illegible records, lack of dwelling numbers and household numbers, differences in names, dates, and ages for the same individuals and events at different times and as reported by different respondents have all created problems in matching. In Thailand, 50 percent of the births and 20 percent of the deaths that had been classified as unregistered, on the basis of matching survey and registration records filed at the district level, were later found to be registered on the basis of either a certificate or an updated household register (Thailand, 1966). This error could not have been detected without careful field checking. Although events were registered at the village level, deficiencies in transmitting and filing the records at the district level, compounded with the difficulties of locating and transcribing all records for each sample unit, resulted in an incomplete registration list.

Pakistan was the only system to attempt initial matching by machine methods and was also the only system to match at one-year intervals. Initial matching in the other systems was done every six months, although after one year Thailand found it possible to shift to a quarterly basis. In the early days of the Indian scheme, matching was done in the field by the survey interviewer at the time of the six-month survey. Testing of this procedure indicated that it reduced independence between the subsystems; initial matching operations were therefore shifted to district or state offices.

All countries utilized third parties for field investigation of unmatched events, although from written descriptions it appears that they are often, if not always, accompanied by the local recorder, perhaps resulting in further loss of independence between subsystems. Maintaining independence between subsystems through initial matching in the office by a third party rather than in the field by the recorder and interviewer is slow and costly. As described by Mauldin (1966), it is "time consuming and expensive both in terms of money and skilled manpower" and "a great strain on one's patience." Considering human nature, however, it seems essential that initial matching be done by a third party. Because of residence, occurrence, geographic, and time period identification problems, many doubtful or questionable matches have been returned to the field for relatively expensive rechecking to determine whether additional data would help in final classification. A problem all systems face is how to organize matching and field recheck procedures for the most efficient utilization of available resources. This involves all other elements of the system that are related to identification procedures. Coverage estimates were typically higher for births than for deaths and highest for multiple-visit household surveys and lowest for civil registration systems. However, coverage within the types of systems varied widely, suggesting that adjustment or calibration factors should be derived separately for each study rather than be based upon other studies. Several studies have found differential match rates by age at death and by age of mother for births. These have demonstrated that there are serious problems of coverage for early infant deaths by both subsystems. Other efforts to identify subgroups with different coverage rates have been minimal in studies reported up to this time.

Finally, there are problems associated with reporting results. In all five systems, except India's, tabulation has been done by machine for both vital events and population. In India each state office prepares a report for each sample unit. Population is tabulated by hand in the field by the survey interviewer immediately after field work for the six-month survey, and vital events are tabulated in the state office.

Substantive estimates from a countrywide system are required by other government agencies for planning purposes. The statistical agency is therefore often pressured to release its data as soon as possible, often in the form of provisional or preliminary estimates. Consumers of this data should always be apprised of its quality and probable limitations including *both* sampling and nonsampling errors (Zarkovich, 1966). Thus far, most country studies have reported only sampling errors and some indications of coverage errors by the two sub-systems. Except for Pakistan and for selected special studies in the other countries, few detailed analyses related to methods research have been published. The Knowledge, Attitude, and Practice Survey with regard to civil registration in Thailand was very informative both in pointing to deficiencies in the civil registration system and in detecting deficiencies in the procedures of the dual record experiment itself (Lauriat, 1967). Little has been published on the magnitude of matching biases and on the extent of out-of-scope events. Unless these procedures are analyzed in detail *within each system* to determine strengths and weaknesses at each stage, improvement is likely to be slow. Furthermore, unless results of such detailed methods studies are communicated to professional colleagues in other countries, they in turn will have to develop their own procedures independently. Knowledge concerning problems encountered in existing systems may be of assistance in setting priorities for research and development in establishing new systems.

IV. The Essential Elements of Dual Record Systems

Essential elements of dual record systems for countrywide or statewide measurement of fertility and mortality are quite similar to those of other national statistical survey systems. They include the whole range of administrative and technical components that encompass the activities involved in planning, organizing, and operating a statistical system. Most of the requirements for single systems have been covered in detail in United Nations publications (United Nations, S.O., 1955, 1958, 1964) and in standard sampling textbooks. Therefore, discussion here will be restricted mainly to elements essential to dual record systems, namely: continuous recording, periodic retrospective surveys, and the matching of events from the two sources including the field recheck of questionable matches. Mapping and field identification, which assumes added importance in a dual record system because of the matching requirements, is also included. Elements essential to a dual system may then be considered as follows.

A. FIELD IDENTIFICATION SYSTEM

This requires a complete map of each sample area (village or urban block) showing clear and unambiguous natural boundary lines that can be identified in the field by a trained field worker visiting the area for the first time. Only minimal assistance should be needed from local persons for general orientation to local landmarks. In addition to clear identification of the boundaries, every building within the boundaries must be numbered so that new construction and the use of each building can be determined at each survey round. In multi-family dwelling units different households should also be assigned separate numbers. Care must be taken to check the completeness and reliability of any pre-existing house-numbering system before deciding that it will serve the purposes of the dual record system. Street people, nomads, and temporary dwelling units, such as tents or straw huts, provide special problems that require development of special procedures fitted to local conditions. The identification system must be updated at each survey round. Reliable procedures for accurate identification of household shifts, both within the sample unit and into and out of the unit, are absolutely essential to controlling geographic boundary errors, especially the use of different boundaries for the same time period

by the two subsystems and the use of different boundaries at different periods by one subsystem. All field workers must therefore be trained in making and in reading maps and must use them at every round.

B. CONTINUOUS RECORDING

In most developing countries a special recording system will be more efficient than use of the civil registration system and is therefore preferred. A local resident recorder, probably part time, who relies upon local informants to find out about events, as in Pakistan and India, has minimal personal contact with sample households. Frequent contact through monthly household visits of the recorder, as in Turkey and Liberia, may condition both respondent and recorder but, more importantly, may influence the response of households to the survey interviewer, thus decreasing independence between subsystems. Neither the local recorder nor his immediate supervisor(s) should be concerned with survey work. He should send monthly reports of vital events directly to survey headquarters with a notice to his supervisor of the day it was mailed. If he keeps a list of vital events it should be withdrawn before the survey team arrives in the sample unit. The recorder's responsibility is to find and report all vital events that occur to visitors within the unit. He must be especially well trained and thorough in determining details of usual residence and place of occurrence, and he must use the household identification numbers accurately.

C. PERIODIC SURVEYS

The survey subsystem should be completely independent of the recording subsystem until the matching stage, with the exception of the use by both subsystems of the same map and house-numbering schemes. Each sample unit should have a baseline household survey and, every six months, a fresh household survey that accounts for every member whether present or absent. Also, a series of detailed questions designed to find out all vital events and migrations during the previous year (six-month overlap) should be asked at every visit. Since each enumeration is fresh, the interviewer must determine whether the household and each number has been in residence for the previous year and, if not, when they arrived. Special care must be taken to determine whether young children represent births within the past year. Infant deaths require special questions. Neighbors must be questioned to find out about families that moved or were dissolved by death in the previous year. Data required for applying stable, quasi-stable, and Brass techniques of estimation should be collected (Brass, 1968b). This includes data on total children ever born for each mother. Interviewers should use the same residence and occurrence definitions as the recorder. Surveys in each unit should be done at roughly six-month intervals and should be conducted as rapidly as possible in each unit. Team or gang enumeration as in Liberia appears to be desirable. A permanent field staff is required in order to maintain a high degree of control over survey operations. For the most efficient use of staff, sample areas might be covered on a year-round rotating schedule, weather permitting, as in Turkey.

Soon after completion of the fresh survey in a unit, records should be sent to headquarters and matched, household by household, against the preceding survey round for the sampling unit, using procedures similar to those followed in Morocco (Sabagh and Scott, 1967). Discrepancies in household size should be noted for later matching with recording or field recheck. Unduplicated records of births and deaths for the half year from the survey would then be known.

D. MATCHING RECORDING AND SURVEY EVENTS

As soon as household discrepancies and records of births and deaths from the survey are available, they should be matched with recorder records for the period. Some household discrepancies might be related to a birth or death recorded by the recorder but missed by the survey interviewer. Unresolved discrepancies in household lists and unmatched births or deaths from the two sources should then be carefully reviewed by experienced senior staff to determine whether or not field recheck is required. If the field identification system is maintained and carefully followed in both subsystems, the number of field rechecks should be minimized except where migration rates are high.[5] As experience with

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[5] In such situations more frequent surveys may be necessary; or perhaps follow-up surveys using previous records would be required rather than fresh surveys.

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matching and field rechecks accumulates, it is possible that matching rules can be modified to reduce the volume of rechecks. Field rechecks should also be done by a mobile field team independent of the recording and survey operations. Perhaps only a single person would be required, since the number of events to be rechecked in any single sample unit should be small. Careful attention should be given in the field check to determining and recording the factors that account for discrepancies between subsystems in order that both subsystems may be improved.

E. QUALITY CONTROL PROCEDURES

Match rates of individual sample units and of individual field workers should be useful as indicators of the quality of field work. Match rates for recorders will usually be based upon relatively few events and hence undue reliance should not be placed on these as the sole indicator of quality. Supervisors should make periodic reports about their personal review of the recorder's work. Timeliness of monthly reporting is another partial indication of quality. Team leaders or supervisors should evaluate and control the quality of interviewer work. Addi-

tional quality checks may be made on matching and field recheck work by deliberately including errors and false reports. The extent to which they are detected is an indication of the efficiency of that particular operation. Special experiments (methods research) with known events can also be introduced into a system to test the relative effectiveness of different procedures in finding such events (Horvitz, 1966).

F. REPORTING RESULTS

A frequent mistake in setting up a new statistical system is underestimating the time required to process data and prepare final reports. Adequate allowance must be made for this in planning, not only for substantive but for technical reports on how well the system functions. Provision must be made at the outset for staff and equipment sufficient to meet deadlines.

Although a high degree of individual presumptiveness and personal judgment was necessary to make the specific recommendations in this section, the research questions posed in the following section should clearly indicate that the specific elements in most instances require further testing.

V. Needed Methods Research in Dual Record Systems

Keeping a proper perspective in posing methods research questions requires that the objective or objectives of the system be kept clearly in mind. The primary objective of a given dual record system may be stated as follows: to produce annual estimates of crude birth and death rates for the country (or state) with a specified level of error (including both sampling and response errors and biases).

The purpose of this discussion can best be served by posing questions that should be answered in designing a *new* countrywide dual system. The same questions may then be asked of existing systems. Review of the experience with related experiments or systems that have been completed or discontinued can be used as a starting point, but naturally these must be considered in relation to the proposed system.

In mounting a large scale sample survey, especially a dual record system, phased expansion should be followed both to obtain estimates of variances, correlations, and perhaps response errors but, more importantly, to gain experience with operational procedures and problems in the field and office, to obtain realistic estimates of workloads, and to develop a cadre of trained people who can gradually expand the system (Som, 1971). From the perspective of developing and implementing a new countrywide system, the following research questions need answers.

A. WHAT IS THE REQUIRED SAMPLE SIZE?

This depends upon the degree of precision required and on the estimates of variances and correlations. It may be sufficiently accurate to assume a Poisson distribution[6] for births and for deaths to obtain estimates of sampling variances. Data on intracluster correlations are needed particularly to determine cluster size for urban areas. Size of cluster in rural areas often has been determined more on the basis of intracluster correlations. Data already available from previous surveys or pretests

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[6] Under this assumption, when the birth rate is (say) 50 per thousand or .05 per person, then the variance is also .05 per person. Detailed discussion of the Poisson distribution can be found in standard introductory textbooks, e.g., Dixon and Massey (1957).
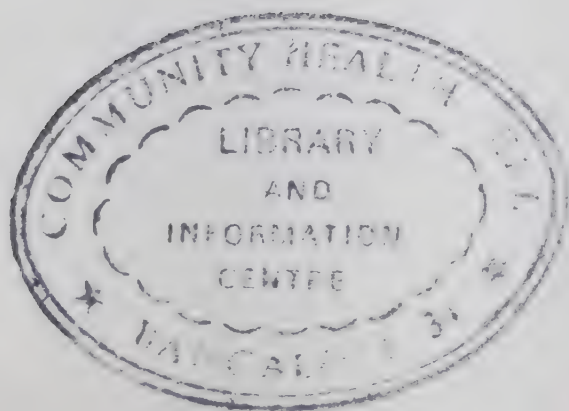
may be analyzed as Scott (Scott, 1968; Scott and Coker, 1971) has done for some African data. The magnitude of geographic boundary errors and problems of identifying migration errors in relation to the size of the sample cluster also need investigation. Such data might be useful for planning better single systems.

B. ROTATION OF SAMPLE VS. FIXED SAMPLE

Is a design that rotates some sample units periodically better than a design in which a fixed sample (of areas) is followed continuously? Some experimentation will be required to estimate the magnitude of time series correlations, conditioning of respondents and interviewers, as well as data on costs of setting up new sample units. Frequency of rotation also is related to the frequency of visits and other field work in the two subsystems. All of these factors plus data on the magnitude of response errors are required to answer this question.

C. WHAT ARE THE BEST RECORDING AND SURVEY SUBSYSTEMS?

Even though special recording subsystems are given a slight edge in Seltzer's analysis (1969), this should be taken only as a hypothesis to be tested. Objective testing of different sybsystems under the specific conditions is required. Feasible alternatives should be tested in interpenetrating samples on a scale large enough and long enough in time to give reasonably good estimates of coverage errors, geographic area and time period errors, and conditioning effects, under field conditions that would prevail in a countrywide system. On *a priori* grounds, it appears that survey coverage requires repeated visits to the same households, i.e., periodic surveys. But experimentation is required to obtain answers to other questions such as frequency of visits and how to ask questions to get the best reporting of events that occur between visits, for example, migrations or early infant deaths. In the absence of knowledge of specific vital events, the only recourse may be to use interpenetrating sample designs; however, the relatively large samples required would be a hindrance. Partial answers could be obtained from experiments similar to those reported by Horvitz (1966) and Mahalanobis (Mahalanobis, 1961;

Mahalanobis and Lahiri, 1960) in which either known vital events or fictitious vital events are "loaded" or "seeded" into interviewer assignments. Although the use of overlapping survey reference periods with matching appears to be very desirable (Mauldin, 1966; Sabagh and Scott, 1967) and necessary to eliminate out-of-scope survey reports within periodic surveys, the remaining extent of undercoverage can be tested only by further matching against an "independent" source such as continuous recording. Evaluation of different subsystems should be based upon match rates for different types of events both before and after field rechecks. Analysis of results of field rechecks of nonmatches and questionable matches can yield information on boundary errors in area and in time and in *de facto-de jure* differences for improving the system.

D. WHAT MATCHING CRITERIA SHOULD BE USED?

This also requires experimentation both to determine how consistently the procedure can be applied in the office and more importantly to determine what evidence should be given the most weight in different situations. The objective should be to develop the combination of matching and field rechecking procedures that yield the lowest error for a fixed expenditure (Marks, 1969). Optimum criteria for matching repeated survey visits with fresh household enumerations on each visit (i.e., matching within the survey system) may well be different from criteria for matching survey events against the recording events.

E. WHAT IS THE MAGNITUDE OF BOUNDARY ERRORS?

Ideally, there should be no compromise for anything less than the best field identification system, but if anything else is used its possible impact should be tested. A full-fledged experiment could be designed to answer this question by using area sampling units and tightly controlled and loosely controlled (or usual) procedures in interpenetrating subsamples. If objective criteria to classify degree of control can be applied to each sample unit within an existing system, it would also be possible to compare errors for different types of units within a system without resorting to an experiment.

F. TO WHAT EXTENT DOES INDEPENDENCE OF THE TWO SUBSYSTEMS INFLUENCE ESTIMATED RATES AND MEASUREMENT ERRORS?

Again, a full-fledged experiment would be possible by comparing, for example, two systems: the first, in which the survey interviewer and recorder work together in the baseline household survey; the interviewer supervises the work of the recorder; and the two work together in field reverification after office matching; and the second, in which "complete" independence between subsystems is maintained and field reverification is done by a fourth party. As an alternative, sampling units within an existing system could be classified by the known or estimated extent of contact between the recording and survey subsystems, and used in analyzing rates and the extent of field problems.

G. WHAT ARE THE PREFERRED METHODS OF ANALYSIS?

By collecting the required data—which may mean lengthy questionnaires—the newer analytic techniques (Demeny, 1971) can be applied to data from dual systems. In any survey, the whole range of available analytic techniques and models should be employed both to test the techniques and to serve as consistency checks (e.g., United Nations, D.E.S.A., 1967). Seltzer (1969) has pointed out that such techniques are complementary to, rather than competitive with, dual record systems. Unfortunately, most of the country systems were designed without giving consideration to collection of all the data necessary for utilizing such techniques. Gathering such data creates additional problems but these techniques should be tested in various cultures.

H. OTHER QUESTIONS

Most specific research questions probably will be related to the rather general research problems discussed above. These would include, for example, the influence on response rates and errors of the length of the survey questionnaire, the type of interviewer and respondent, and related factors. Specific approaches that should be tested include: methods for improving age reporting (Brass, 1968a; Scott and Sabagh, 1970) and actuarial accounting techniques for analysis (Arretx and Somoza, 1965). The answers to these questions, and to others needing consideration, ideally should be sought through well-designed and tightly controlled experiments conducted as part of the ongoing survey operation. However, research on such questions can also be conducted by other research institutions both within and outside a country. Results of such research outside the system may then be modified and tested within the system. Phased expansion of a system in time is essential, with reasonable attention being given to quality control at every stage.

VI. Discussion

This admittedly selective review, which has covered (1) the emergence of the dual record system as a general method for measuring vital rates and (2) the other methodological research, was done with two objectives. The first objective was to emphasize the potentials of dual record systems as self-checking systems in their own right. The second objective was to emphasize further that in the absence of some means of self-checking, for example, reinterviews or record checks, the quality of data produced by any single system is unknown. In dual record systems, all the problems of single systems are encountered, plus other problems introduced by the necessity to coordinate the work of the two subsystems and to match individual records. This coordination and matching feature is a necessity rather than a luxury of the dual system, whereas with single systems such cross-checking is often "icing on the cake" and has relatively low priority. Even when high priority is given to cross-checks at the planning stage, when costs and time requirements are underestimated, the cross-checks and quality checks are the easiest features to sacrifice. The tendency to do this is present, of course, in dual systems as well, but it is less likely to occur since cross-checking is defined as an essential feature.

It may be argued that dual systems are too expensive for developing countries, but no one questions the need for vital statistics data of known quality. Some cross-checking of a multiple record nature is required to fill the latter need; therefore, the problem reduces to the determination of the quality level required in the data. In demographic measurement, controlling quality means controlling nonsampling errors, since these usually are more serious than sampling errors. For any system, dual or single, this means in general sound design, well-trained personnel, and firm control over all phases of data collection and processing. Without these, any system will fail; with these, and with adequate cross-checking, assessment of quality can be made. Cross-checking that involves unit matching of records means in effect a dual system. Cross-checking aggregated data from two or more single systems of unknown quality may be misleading. Hence, some type of dual system seems essential for vital statistics in countries with inadequate vital registration.

Dual record systems are not a panacea. Some advantages are:

1. The system is self-checking and hence can produce data of known quality.
2. Because of the self-checking feature, it is relatively easy to experiment and measure the effect of changes in the system.
3. There is flexibility in changing some of the content of panel surveys from time to time.
4. There are indications that the total error may be considerably less than for a single system with much larger samples.

The main apparent disadvantage is increased cost for a given sample size because:

1. It is more complex to administer than a single system.
2. It requires a higher ratio of well-trained personnel than a single system.

More research is required to determine when both dual record and single survey systems are sufficiently accurate to fill the needs for fertility and mortality data. In the interim, dual record systems can yield better estimates and also provide a framework for evaluating different single systems.

While these conclusions are not new, the accumulation of evidence based upon experience in both dual systems and other measurement research tends to advance the conclusions much closer to fact and away from their former position of conjecture and theory.

ACKNOWLEDGMENTS

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Occasional Publications

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A GLOSSARY OF SELECTED DEMOGRAPHIC TERMS (July, 1974)

A HANDBOOK FOR POPULATION ANALYSTS by Joan W. Lingner (August, 1974)